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(54) INK JET RECORDING APPARATUS

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Specification

Title of the Invention: INK JET RECORDING APPARATUS

1. An ink jet recording apparatus comprising a nozzle having an ink supplied thereto under pressure, means for applying vibrations to the nozzle and ejecting ink particles from said nozzle, charging and deflecting means which charges the ink particles sprayed from said nozzle and deflects the charged ink particles, and means for transporting a recording material which is moved with respect to said nozzle and has practically the same size in the movement direction, wherein the prescribed letters are recorded on said recording material by the ink particles ejected from said nozzles, this apparatus being characterized by the fact that it comprises detection means which contains one detector, detects the movement of the recording material past the position of the detector, and outputs a recording material presence signal, measuring means which measures a movement time required for the whole length of the recording material to move past the detector position from the recording material presence signal, and control means which controls the period of said deflection according to the measured movement time, thereby maintaining a constant letter width against changes in the motion speed of the recording material.

Detailed Description of the Invention

The present invention relates to an ink jet recording apparatus. More specifically, the present invention relates to an ink jet printing apparatus in which vibrations are applied to ink sprayed under applied pressure to obtain ink particles, and the obtained particles are charged and deflected to record letters, number, or symbols (all these images taken together are referred to as letters below). In particular, the present invention was developed so as to maintain a constant letter width, regardless of changes in the motion speed of the recording material, thereby preventing the degradation of letter quality, and to eliminate problems associated with bulging of the recorded letters from the specific zones on the recording material.

Ink jet recording apparatus are capable of high-speed contactless recording of letters on a recording material. For this reason they have found application not only as terminal printers for computers, but also as apparatus for direct printing of date and the like on commercial products transported on a conveyor in a manufacturing process. In such apparatus, letters are formed by

deflecting ink particles in the direction perpendicular to the motion direction of the recording material. Therefore, the height of recorded letters is determined by the amount of ink particle deflection, and the width of letters is determined by the motion speed of recording material and the deflection period of ink particles. Usually to make the letters easily readable, a constant relationship should be maintained between the letter height and width. Unless this relationship is maintained, not only the letter quality is degraded but other unfavorable results are obtained, such as bulging of parts of letters from the set zones on the recording material. Thus, it is desired that a constant relationship be maintained between the motion speed of the recording material and the deflection period of ink particles. However, the motion speed often changes depending on production rate and when the conveyor is stopped and started. To address this issue, two systems have been used. With the first system, the deflection period was controlled according to the output of a speed detector installed in a conveyor driving apparatus. With the second system, two detectors were installed and the deflection period was controlled according to the time required for the recording material to pass between the detectors (Japanese Patent Application Showa 53-83999).

However, the following problems were associated with the above-described conventional systems. In the first of them, the installation of detector was a difficult task and the slip of conveyor or recording material could not be detected. In the second system, two detectors were required which resulted in the increased cost.

It is an object of the present invention to resolve the above-described problems inherent to the conventional technology and to provide an ink jet recording apparatus which can consistently conduct accurate recording, even if the motion speed of recording material changes, with a single detector.

A specific feature of the present invention designed according to the general characteristic of the usual production lines (a recording material of the same size is supplied in a continuous mode) is that the ink jet recording apparatus comprises detection means which contains one detector, detects the movement of the recording material past the position of the detector, and outputs a recording material presence signal, measuring means which measures a movement time required for the whole length of the recording material to move past the detector position from the recording material presence signal, and control means which controls the deflection period of ink particles according to the measured movement time.

An embodiment of the present invention will be described below with reference to Fig. 1, Fig. 2, and Fig. 3. Fig. 1 shows the structure of the recording portion of this embodiment. In this figure, the reference symbol 1 stands for a nozzle head of an ink jet recording apparatus, 2 stands for a recording material which is transported by a belt conveyor 3. The reference symbols 4a, 4b stand for the elements of a detector of an optical beam interruption type, which detects the presence of the recording material 2. The element 4a is a light-emitting element, the element 4b is a light-receiving element. The prescribed letter is recorded by a nozzle head 1 once the whole length of the recording material 2 has moved past the position of detector 4a, 4b.

Fig. 2 is a block diagram illustrating the structure of this embodiment. In the structure shown in Fig. 2, a clock signal (represented by symbol *f* identical to generated frequency *f*) produced by a generator 11 is converted into a sinusoidal wave by a filter circuit 12, amplified by an amplifier 13 and applied to an oscillator 6 mechanically bonded to a nozzle 6. As a result, the nozzle 6 vibrates with an oscillation frequency *f*. On the other hand, an ink is supplied under pressure to nozzle 6 from the direction shown by an arrow in the figure. This ink is transformed into particles by the vibrations of nozzle 6 and synchronously with the clock signal *f*, and the particles are ejected. Ink particles 9a required for recording are charged by a charging electrode 7 which is under a voltage corresponding to a letter signal. The charged particles are deflected to a degree corresponding to the amount of charge by a deflection electrodes 8a, 8b forming an electrostatic field by a DC high voltage HV. The deflected particles adhere to the recording material 3, forming a letter. Among the ink particles from the nozzle 6, those which are not used for recording (ink particles 9b) are recovered by in a gutter 10 and reused.

The reference symbol 14 stands for a memory which stores the content read out by a letter counter 17. The stored content is sent into a pattern memory 15. The pattern memory 15 produces a pattern signal by employing the stored content from the memory 14 and the output of a column counter 18, and this pattern signal is input into a pattern signal shaping circuit 16. The pattern signal shaping circuit 16 shapes a step-like video signal according to the pattern signal from the pattern memory 15 and the output of a row counter 19, and this video signal is applied to the charging electrode 7 via an amplifier 29. The row counter 19 is shifted by the clock signal *f* and reset by a scanning completion signal 8 output for each single deflection scanning. Furthermore, the column counter 18 is shifted with the completion of each scanning and reset when the preset value is reached. At the same time, the letter counter 17 is shifted. When the

present number of letters is reached in letter counter 17, a recording completion signal is output into the below-described flip-flop circuit 20 (abbreviated as FF below).

A detection signal A output from the light-receiving element 4b is input into the FF circuit 20 and an AND gate 21. If the detection signal A from the light-receiving element 4b corresponds to level "1" when the recording material 2 interrupts the light beam, the AND gate 21 opens the gate, and the clock *f* is input into a frequency division circuit 22. The output of the frequency division circuit 22 is input into a counter 23. If the frequency division ratio in the frequency division circuit 22 is denoted *n*, then the counter is shifted by the *f/n* clock signal. When the recording material 2 is transported past the position of the light-receiving element 4b and the detection signal A corresponds to level "0", the AND gate 21 closes the gate, shifting of counter 23 is terminated, and at the same time the FF circuit 20 comes to a set state.

When the FF circuit 20 comes to a set state, that is, when the output B corresponds to level "1", a one-shot multivibrator (abbreviated as OM below) 24 outputs a pulse signal C. This pulse signal C transfers the content of counter 23 into a register 25, and then the counter 23 is reset. Furthermore, when the FF circuit 20 comes to a set state, the AND gate 26 opens the gate, the clock signal *f* is input into the counter 28, and the counter 28 starts to shift. If the content of register 25 matches the content of counter 28, a comparator 27 produces a scanning completion signal S, and the counter 28 is reset by this scanning completion signal S. As a result, the counter 28 is shifted, resetting is repeated, and such operations are continued till the FF circuit 20 is reset by the recording completion signal.

The operation of the apparatus of this embodiment, which is shown in Fig. 2 and has the above-described structure, will be explained below with reference to Fig. 3. Here, the recorded letter consists of a (7 rows x 5 columns) dot matrix. Signals S~E shown in Fig. 3 correspond to signals shown in Fig. 2. When the recording material 2 interrupts the light received by the light-receiving element 4b and the detection signal A corresponds to level "1", a clock signal D is input into the frequency-dividing circuit 22 and the counter 23 is shifted. When the level of detection signal A corresponds to "0", the generation of clock signal D is terminated, and shifting of counter 23 is terminated. At the same time, the FF circuit 20 comes to a set state, its output signal B corresponds to level "1", the clock signal E is input into the counter 28, and shifting of counter 28 is initiated. Furthermore, since the FF circuit 20 has come to a set state, a pulse signal C is output from OM 24, and the content of counter 23 is transferred into the register 25. If the content of counter 28 matches the content of register 25, a scanning completion signal 8 is output

from the comparator 27, the counter 28 and row counter 19 are reset, the column counter 18 is shifted, and scanning of the next column is initiated. This operation is repeated until the output signal B of FF circuit 20 becomes "0", in other words, till the recording of all the letters is completed.

A method for determining the frequency division ratio n of frequency dividing circuit 22 will be described below. In order to prevent undesirable results, such as the decrease in the quality of recorded letters or bulging of letters from the preset position on the recording material 2, the dot pitch P_n in the column direction of letters should be maintained constant even if the motion speed of recording material 2 changes. If the size of recording material 2 in the movement direction (referred to as the whole length of recording material) is denoted by l, the motion speed is denoted by V, the frequency of clock signal f is denoted by f, and the frequency division ratio of frequency dividing circuit 22 is denoted by n, then the count a of counter 23 will be represented by the following formula because it is the count of input clock signal f/n, within the time l/V required for the whole length of recording material 2 to move past the position of the light-receiving element 4b.

$$a = \frac{l}{V} \cdot \frac{f}{n} \quad \cdots\cdots\cdots\cdots (1)$$

On the other hand, the count b of counter 28 will be represented by the following formula (2) because it represents the count of the input clock signal f within the time P_n/V required for the recording material 2 to pass the distance corresponding to a dot pitch P_n.

$$b = \frac{P_n}{V} \cdot f \quad \cdots\cdots\cdots\cdots (2)$$

The comparator 27 detects a state in which the count a is equal to count b and outputs a scanning completion signal S. Therefore, if the condition $a = b$ is satisfied, the following formula can be derived from formulas (1) and (2).

$$P_n = \frac{l}{n} \quad \cdots\cdots\cdots\cdots (3)$$

As follows from formula (3), the dot pitch P_n does not relate to the motion velocity V and relates only to the whole length l of recording material 2 and frequency division ratio n. Conversely, if the frequency division ratio n is set based on the whole length l of recording material 2 and dot pitch P_n, as represented by formula $n = l/P_n$, then recording can be conducted with a constant dot pitch P_n. Therefore, it is possible to resolve the problems associated with the conventional apparatus, that is, the degradation of letter quality caused by changes in the motion speed and bulging of the letters from the specific areas on the recording material.

As described above, in accordance with the present invention, a system is realized which uses a single detector and measures the motion time required for the whole length of the recording material to move past the detector. Therefore, recording with a constant letter width can be conducted even when the motion speed of recording material is changed.

Brief Description of the Drawings

Fig. 1 is a schematic view of the recording portion of an embodiment of the present invention. Fig. 2 is a block-diagram of an embodiment of the present invention. Fig. 3 is a diagram used to explain the operation of embodiment shown in Fig. 2.

2 – recording material, 4a – light-emitting element, 4b – light-receiving element, 5 – oscillator, 6 – nozzle, 7 – charging electrode, 8a, 8b – deflecting electrodes, 9a, 9b – ink particles, 11 – generator, 12 – filter circuit, 15 – pattern memory, 16 – pattern signal shaping circuit, 17 – letter counter, 18 – column counter, 19 – row counter, 22 – frequency divider, 27 – comparator.

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Figure 1

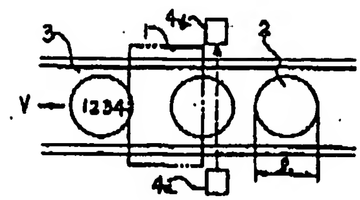
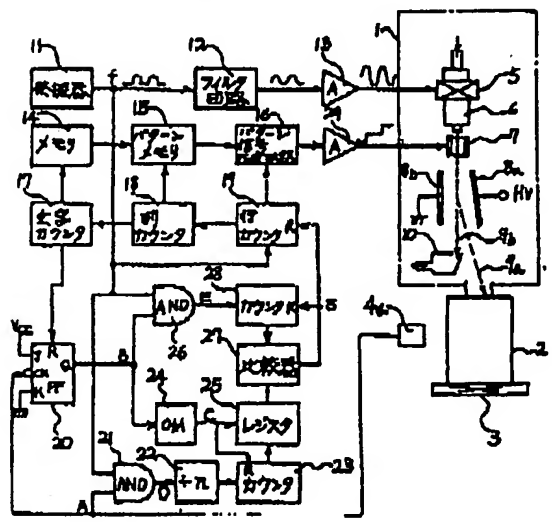


Figure 2



Key to figure: 11 – generator, 12 – filter circuit, 14 – memory, 15 – pattern memory, 16 – pattern signal shaping circuit, 17 – letter counter, 18 – column counter, 19 – row counter, 22 – frequency divider, 23 – counter, 25 – register, 27 – comparator, 28 – counter

Figure 3